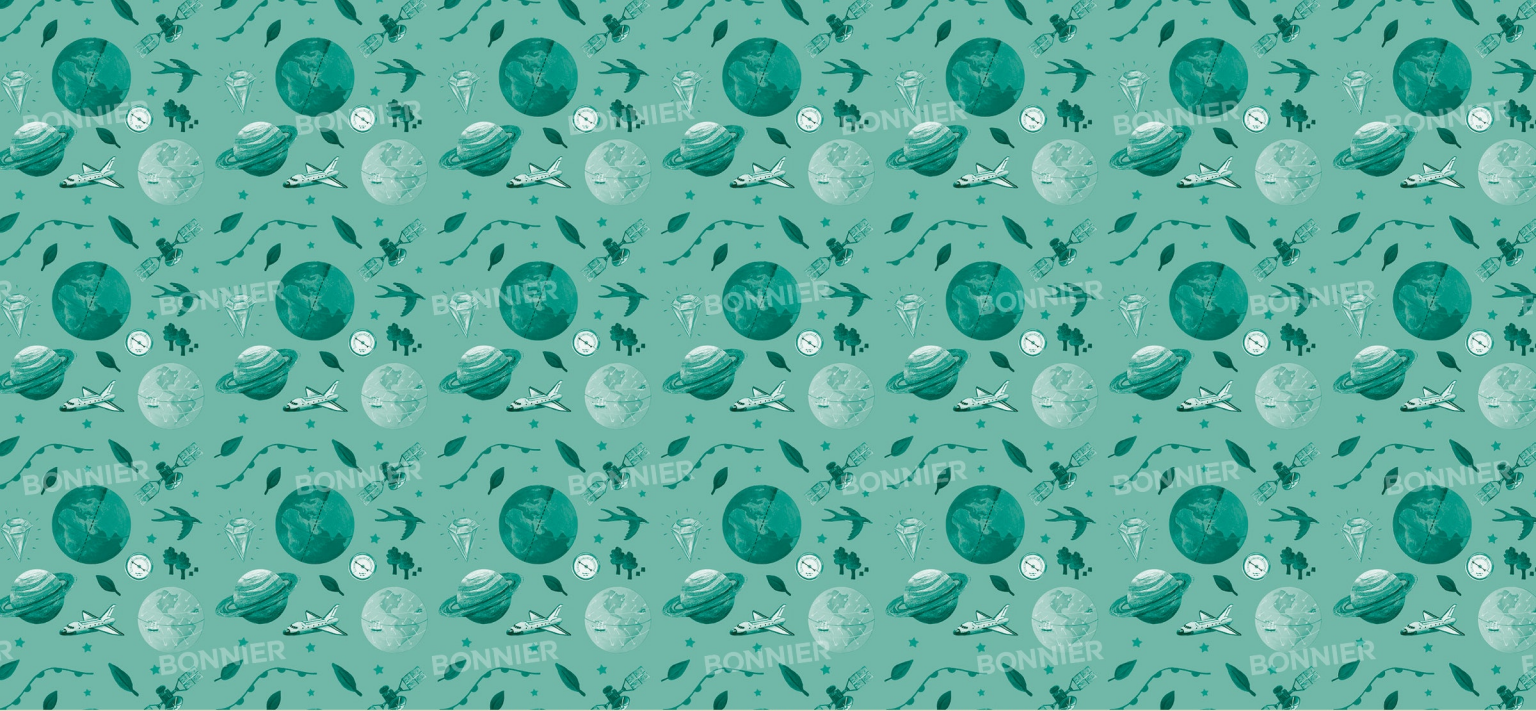
HOW THE WORLD WORKS

Discover
our amazing planet
and its wonders!

This book belongs to:



To Phil, Tom and Nico – C.D.

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HOW THE WORLD WORKS

By Christiane Dorion and Beverley Young

templar books

What on Earth happened?

We live on a unique planet, which travels around one of billions of stars in our Universe. But how did it all begin? Astronomers think that 13.7 billion years ago, the whole Universe emerged from a tiny invisible dot. Mind-boggling, isn't it?

The Sun

The Sun is the closest star to us and is at the centre of our Solar System. It is a massive ball of burning gas that produces light and heat. Without the Sun, there would be no life on Earth.

The planets

Eight planets travel around, or orbit, the Sun at different speeds, rotating like spinning tops. The four planets closest to the Sun, including Earth, are made of rocks and metals. The four outer planets are bigger and are made of gas.

So, which planet is which?
1. Mercury 2. Venus 3. Earth 4. Mars 5. Jupiter 6. Saturn 7. Uranus 8. Neptune

Asteroids

Asteroids are chunks of rock left over from the formation of the Solar System. Millions travel around the Sun between Mars and Jupiter.

Comets

Comets are giant lumps of ice and dust that orbit the Sun. As they come close to the Sun, they begin to melt, leaving an impressive trail behind them.

Did you know that Pluto isn't considered a planet any more? It's too small! It's now called a dwarf planet.

The Big Bang!

Where did all this come from?

Try to imagine Earth, the Moon, the Sun, the planets and the stars all squeezed together into something so small it's invisible. This is how we think the Universe started.

In less than a second, this invisible dot expanded incredibly fast, throwing out lots of dust, gas and other particles. Over billions of years, these gradually stuck together to form all the stars, planets and moons in the Universe.

What goes around...

comes around. Over time, we have put thousands of objects into orbit around the Earth to learn more about our planet and what lies beyond it.

Space station

The International Space Station is as big as a football pitch. It was built by 15 countries working together so that astronauts can live in space for months on end.

Hubble telescope

This telescope is the size of a bus. It takes photographs and collects information about the Universe.

Satellites

Satellites take pictures of the Earth to forecast the weather and make maps. They also bounce signals across the globe for communication, radio and television.

Space junk

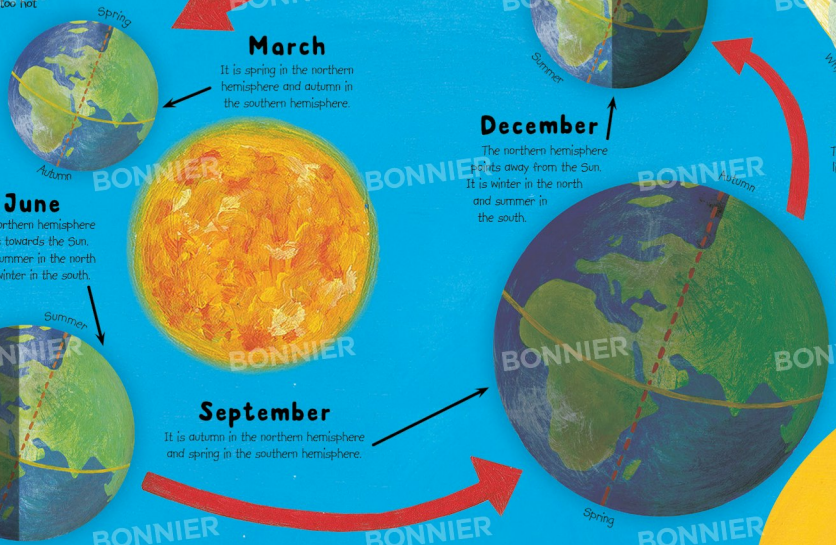
Millions of nuts, bolts, tools and other objects left over from rockets and satellites or dropped by astronauts are still floating around Earth. There's a lot of junk out there!

Why is Earth unique?

As far as we know, Earth is the only planet in the Solar System where life can exist. The conditions are perfect: it's not too hot or too cold, there is air to breathe and water to drink.

Earth's orbit

The Earth leans to one side while spinning around the Sun. This tilt creates the seasons because as Earth travels around the Sun, different areas receive different amounts of sunlight.



Earth facts!

Age: Nearly 4.6 billion years old

Length of year (the time it takes to orbit the Sun): 365 days, or, to be precise, 365 days, 6 hours, 9 minutes and 9.54 seconds!

Diameter: 12,756 Kilometres (as planets go, Earth is quite small!)

Day and night

The Earth rotates once in 24 hours. As it spins, one side is lit by the Sun, and it is daytime. The other side is dark, and it is nighttime. Imagine that the torch is the Sun and the ball is Earth.

The Moon

Our nearest neighbour in space is the Moon: a huge ball of rock. The Moon orbits Earth, so every night we see a different part of it lit up by the Sun. This is why it seems to change shape in the sky.

What if there was no Moon?

Earth would spin faster, so the days would be much shorter. The Moon's gravity slows down the Earth's rotation.

Gravity

If you drop something, it falls to the ground. This is because of gravity, a force that makes the objects in the Universe pull towards each other. Earth's gravity pulls us towards the ground, stopping us from whizzing off into space. Gravity also keeps the planets in orbit around the Sun and the Moon in orbit around the Earth.

When did life begin?

The answer is 3.8 billion years ago! When the Earth formed (around 4.6 billion years ago), it was a lifeless ball of molten rock wrapped in poisonous gas and bombarded by meteorites. It was very dark and very hot. Millions of years later, the first signs of life appeared and changed very slowly into today's plants and animals.

The woolly mammoth and other big mammals developed 65 million years ago.

About 170 million years ago, the biggest reptiles of all, the dinosaurs, roamed the Earth.

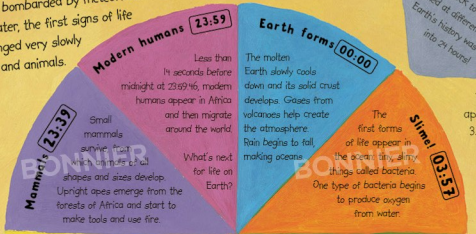
The first reptiles appeared 360 million years ago. This one is called Dimetrodon.

Plants spread over the land 440 million years ago.

Giant woodlice called trilobites appeared in the sea 545 million years ago.

Fossils help us find out about ancient plants and animals.

The first bacteria appeared in the ocean 3.8 billion years ago.



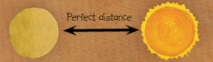
Earth's history in 24 hours!

Imagine the whole history of the Earth squeezed into a day. One minute would equal about 7 million years, and one second 80,000 years! Look to the clock to find out what happened at different times if the Earth's history was squeezed into 24 hours!

How did life begin?

Nobody knows for sure. Scientists agree that a very long time ago, life sprang from chemicals floating in the oceans. What we don't know is exactly how these chemicals turned into life.

Recipe for life

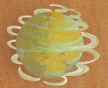


1. Find a planet.
It should be just the right distance from a star, so it is not too hot and not too cold, just like Earth.

2. Bring the volcanoes to a boil.
When they erupt, the surface of the planet will be covered with burning hot lava.

3. Add a rocky moon.
This will stop the planet from spinning too fast.

4. Add an atmosphere.
Release gases from the volcanoes to create an atmosphere which will cool the planet down. Stir until you have the right mixture of gases, moisture and warmth.



5. Cool and add water.
Cool the planet for billions of years, then throw icy comets at it. In the atmosphere, the ice will turn into vapour. This will cause rain to fall, creating oceans.

6. Add the special ingredients for life.
Season the oceans with carbon, hydrogen, oxygen, nitrogen, a pinch of calcium, sulphur and other elements. Mix well.

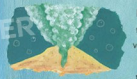
Evolution

The British scientist Charles Darwin carefully studied fossils of plants and animals. He described how living things have evolved over millions of years to suit the different environments in which they live. In 1859, he came up with the idea that all living things, from trees to fish to humans, come from one common ancestor. In a nutshell, we're all descended from slimy bacteria!

How did these chemicals turn into life?

1. Primordial soup
One idea is that life started in shallow pools containing a brew of chemicals. Then lightning sparked a chemical reaction that turned simple molecules into more complex ones called amino acids – the vital ingredients for life.

2. Meteorites
Another idea is that amino acids came from meteorites hitting the planet billions of years ago.



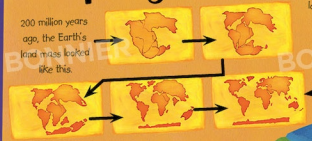
3. Hydrothermal vents
Now scientists believe that life began near vents in the sea floor, where hot, volcanic gases rich in minerals bubbled up from the Earth's core. These minerals may have provided food and warmth for early forms of life.

Another theory...
Some people think that life on Earth is the result of experiments by aliens who sent life to the planet millions of years ago, but this is very unlikely!

Since humans turned up, the flightless dodo bird, the Tasmanian tiger and many more animals have become extinct.

Pangaea

200 million years ago, the Earth's land mass looked like this.



The continents as we know them today.

Have you ever noticed that the continents could fit together like the pieces of a jigsaw puzzle? Scientists believe that a long time ago, the continents were joined together to form one huge land mass, called Pangaea. About 200 million years ago, this supercontinent started to break apart, spreading out to form today's continents.

Pangaea's landscape would have been covered in tropical ferns and palm trees.

This map shows Earth's main tectonic plates. The arrows show the direction that the plates are moving.

Earth is made up of different layers. The outer layer, called the crust, is broken up into big pieces called tectonic plates. These float on a thick layer of hot, flowing rock called the mantle. Over time, the movement of these plates creates mountains, volcanoes and earthquakes on the Earth's surface.

Is the Earth moving beneath our feet?

In a word, YES! While you are reading this book, the Earth's surface is moving at a speed of up to 12 centimetres a year!

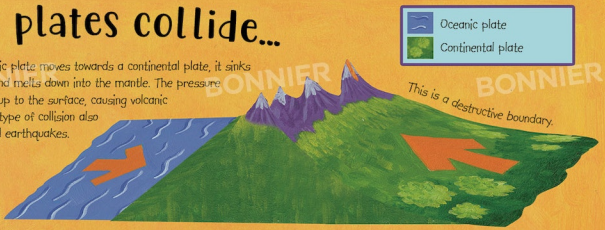
How do we know that the plates move?

All over the world we can see evidence of this:

1. **San Andreas Fault**
   The plates slide against each other, creating earthquakes.
2. **Mid-Atlantic Ridge**
   The sea floor is spreading because the plates are moving apart, creating a long, high ridge under the sea.
3. **Himalayas**
   These mountains were formed because two plates collided.
4. **Krakatoa**
   This volcanic island is part of the Ring of Fire: a chain of volcanoes around the Pacific caused by plates colliding.

When plates collide...

When an oceanic plate moves towards a continental plate, it sinks underneath it and melts down into the mantle. The pressure forces magma up to the surface, causing volcanic eruptions. This type of collision also causes powerful earthquakes.

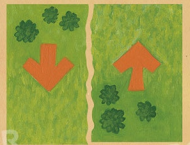


When two continental plates collide, the crust buckles to form mountains. As the plates continue to move towards each other, the mountains become taller.

When plates slide...

If two plates slide past each other, a huge amount of friction is caused and this sudden movement creates earthquakes. More than one million quakes rattle the Earth each year!

The Richter scale measures the size of an earthquake. 1 is mild, 10 is EPIC!



This is a conservative boundary.

When plates move apart...

Where oceanic plates move away from each other, magma rises from the mantle, creating new crust. A chain of volcanoes can form here. If a volcano rises high enough, it can make an island.

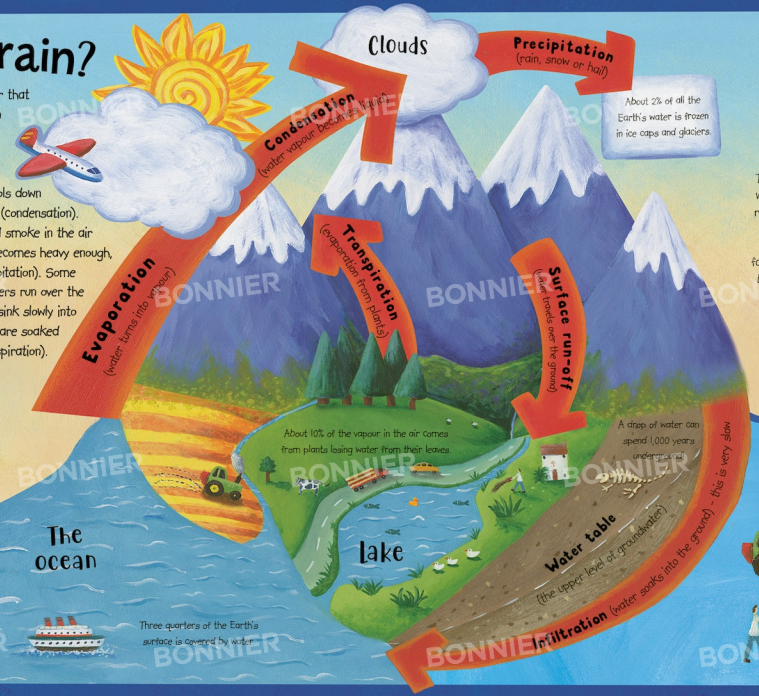
This is a constructive boundary.
The world's largest active volcano is Mauna Loa in Hawaii.

Why does it rain?

The Earth has a fixed amount of water that keeps going around in a cycle between the ocean, the air and the ground.

The Sun heats the surface of rivers, lakes and oceans, turning water into vapour. Vapour rises into the air, cools down and turns back into water droplets (condensation). These stick to particles of dust and smoke in the air and make clouds. Once a droplet becomes heavy enough, it falls down as rain or snow (precipitation). Some drops land in rivers and oceans, others run over the ground to reach them. Some drops sink slowly into the ground (infiltration), while others are soaked up by plants to evaporate again (transpiration).

Isn't it amazing that the water molecules in your body might have been part of a dinosaur millions of years ago?



How do we get our water?

To access clean water, humans create a diversion in the water cycle. We take water from underground sources, rivers or lakes, and pump it into constructed reservoirs. This water goes to a treatment plant to be cleaned. Then, it is pumped into homes, schools, offices and factories through pipes buried in the ground. Once it has been used, dirty water goes into different underground pipes called sewers, which carry the water to the sewage plant. The water is cleaned once again and pumped back into rivers, where it continues its journey through the water cycle.

How do we interfere with the water cycle?

Billions of plants and animals share the planet and they all depend on water to live. But we use much more water than other species and change its quality for the worse.

Farming

Fertilisers and pesticides can seep into rivers and lakes, polluting the water.

Transport

Our vehicles release harmful gases into the air. This makes the rain acidic and affects trees and wildlife.

Spilling oil

Oil poured into drains and rivers, or leaking from cars and lorries, pollutes the water.

Logging

Chopping down forests means that rain runs quickly over the ground instead of sinking slowly into the soil.

Why does the weather change?

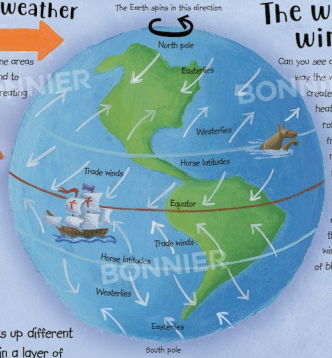
Simply put, the weather changes because the Sun heats up different areas, which drives the winds. The Earth is wrapped in a layer of gas called the atmosphere. Changes in the weather happen in the lower level of the atmosphere – the troposphere. Here, the air is always on the move, carrying heat and water around the globe.

The Sun drives the weather

Less heat near the poles

The Earth is round, so the Sun heats some areas more than others. The air moves around to even out the temperature, creating the winds.

More heat at the equator



The world's winds

Can you see a pattern in the way the winds blow? It's created by the Sun's heat and the Earth's rotation. Warm air from the equator moves towards the poles, and cold air from the poles moves towards the equator. Because the Earth spins, the winds swerve instead of blowing straight.

What's in a name?

The trade winds were named because ships carrying goods to trade used them to sail the oceans. In the horse latitudes where winds are light, ships were sometimes becalmed, so voyages were prolonged. Sailors were forced to throw their horses overboard to save water.

Warm meets cold

Clouds and rain form when two huge air masses with different temperatures and amounts of moisture come together from different directions. The boundary between them is called a weather front.

Cold front

Colder air advances towards warmer air. The colder, heavier air pushes under the warmer, lighter air and forces it to rise vigorously. Cold fronts bring heavy rain followed by cool weather.

Warm front

Warmer air meets colder air. The warmer air rises gradually over the colder air. Warm fronts are more gentle than cold fronts, bringing light, steady rain followed by warm weather.

What's the forecast?

Thanks to information from satellites, ships, hot-air balloons and ground instruments, meteorologists can predict the weather. But if you are planning a picnic, play it safe and take an umbrella!

Temperature

This is a measure of how hot or cold the air is. It depends on how sunny and windy it is and where you are on the planet.

Air pressure

Air pressure is the weight of the air pressing down on the Earth's surface. When warm air rises, the pressure is low. This brings clouds and rainfall. When air sinks, the pressure is high. This leads to clear skies with few clouds.

Wind speed

Wind is caused by differences in temperature and air pressure between two areas. The bigger the differences, the stronger the wind.

Predicting the weather ...naturally

Long ago, before weather forecasts existed, sailors and farmers relied on clues from nature to predict the weather. The results weren't always perfect, though!

Pine cones...

open up when the air is dry.

Crickets...

chirp faster in warm weather.

Seagulls...

fly to land when a storm is near.

Cows...

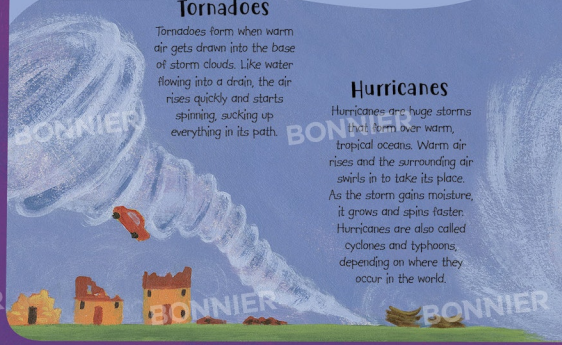
lie down on a dry patch before it rains.

What is extreme weather?

Weather can be dangerous! Winds and rain help move heat and water around the Earth. But extreme weather can cause huge damage to homes, buildings and roads, and can even be deadly. Scientists now know that human activities are changing our atmosphere and making the Earth warm up. This is likely to bring more extreme weather in the future!

Tornadoes

Tornadoes form when warm air gets drawn into the base of storm clouds. Like water flowing into a drain, the air rises quickly and starts spinning, sucking up everything in its path.



Hurricanes

Hurricanes are huge storms that form over warm, tropical oceans. Warm air rises and the surrounding air swirls in to take its place. As the storm gains moisture, it grows and spins faster. Hurricanes are also called cyclones and typhoons, depending on where they occur in the world.

Extreme winds

The air above our heads can move very fast, creating gales and hurricanes. Tornadoes produce the fastest winds on Earth – sometimes travelling close to 480 kilometres per hour!

Force	Description	Observation	Wind speed
0	Still	Smoke rises	0 km/h
1	Calm	Smoke drifts	1–5 km/h
2	Light breeze	Leaves rustle	6–11 km/h
3	Gentle breeze	Leaves and twigs move	12–19 km/h
4	Moderate breeze	Branches move	20–29 km/h
5	Fresh breeze	Small trees sway	30–39 km/h
6	Strong breeze	Large branches move, difficult to use an umbrella	40–50 km/h
7	Near gale	Large trees sway	51–61 km/h
8	Gale	Twigs break, difficult to walk	62–74 km/h
9	Strong gale	Roofs damaged, signs and antennae blown down	75–87 km/h
10	Storm	Trees blown down, damage to buildings	88–102 km/h
11	Violent storm	Serious damage to buildings and countryside	103–117 km/h
12	Hurricane	Violent destruction	over 117 km/h

The Beaufort scale is a way of measuring wind speed by looking at visible clues. It was devised in 1806 by a British naval officer called Francis Beaufort to help sailors rank wind conditions.

What is carbon?

Carbon is one of the natural substances that make up everything in the world. It is in the air, the rocks, the oceans and all living things, including you. There is a fixed amount of carbon on Earth and it is reused over and over again. Look at the natural carbon cycle below, then find out how we interfere with this cycle.

Did you know that diamonds are made of one of the most common substances on Earth? Carbon!

Fossil fuels

Oil, coal and natural gas are called 'fossil' fuels because they come from dead plants and animals buried underground millions of years ago. We burn them to produce energy, so the petrol in your car comes from living things that existed before the dinosaurs! When we burn fossil fuels, carbon that was stored underground gets released quickly into the atmosphere. This leads to global warming.

The carbon cycle

Carbon moves around all the time between the sea, the atmosphere, the ground and living things.

There is a constant exchange of carbon between the air and the ocean.

Carbon in the atmosphere

Living things release carbon when they breathe.

Animals get their carbon from eating plants or other animals that have eaten plants.

Plants extract carbon from the air to make food.

In the air, carbon is attached to oxygen to form a gas called carbon dioxide.

Carbon moves from the ground to the air when rocks break down or volcanoes erupt.

When we burn trees, carbon goes into the air.

Factories and power stations release carbon from fossil fuels.

Every time we travel by car, switch on a light or fly abroad, we add carbon to the atmosphere.

When living things die, they slowly decay, putting carbon back into the soil.

Some plant and animal remains are crushed underground for millions of years, creating fossil fuels.

Bacteria and fungi release some carbon by breaking down dead plants and animals.

As we cut down forests, there are fewer trees on the planet to soak up carbon from the air.

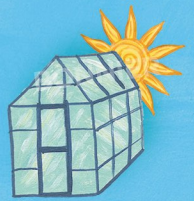
We extract oil, coal and natural gas from the Earth. We burn these fossil fuels to power factories and produce electricity.

The human influence

The world has changed fast over the last hundred years. An increasing number of people, factories, power stations and cars keep adding carbon to the air that the planet cannot absorb. These are the ways humans are meddling with the natural carbon cycle.

How is Earth like a greenhouse?

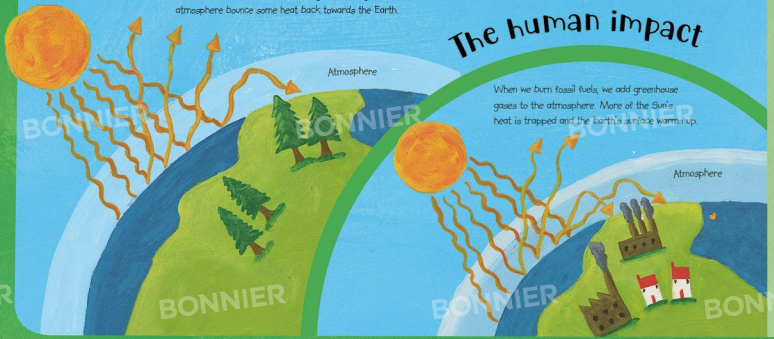
The atmosphere naturally contains gases, such as carbon dioxide, which trap heat from the Sun and keep the planet warm. These are called greenhouse gases, and without them, the planet would freeze. But human activities are pumping more greenhouse gases into the atmosphere, so the Earth is getting warmer.



The Earth's atmosphere is like a greenhouse trapping the Sun's heat.

The natural greenhouse effect

When the Sun's rays reach Earth, some are reflected back into space by the Earth's surface. But greenhouse gases in the atmosphere bounce some heat back towards the Earth.



The human impact

When we burn fossil fuels, we add greenhouse gases to the atmosphere. More of the Sun's heat is trapped and the Earth's surface warms up.

What is a carbon footprint?

It is the impact we have on the planet. When we switch on a light, use the computer or fly abroad, we probably use fossil fuels which add carbon dioxide and other greenhouse gases to the atmosphere. You can measure how much you produce from different activities. Each of us has a carbon footprint, and so do all of the products we buy and use every day. Buying food, clothes and other things produced far away means that more fossil fuels are being burned to transport them, putting more greenhouse gases into the air. Of course, having a small carbon footprint is much better for the planet than having a big one!

Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone and water vapour.

How can we reduce our carbon footprint?

The best way is to use less energy. We can start at home by turning down thermostats, hanging out the washing rather than tumble drying it and switching off lights, televisions and computers when not needed. Transport is another big carbon producer. Walking, cycling or using public transport really helps. Small actions can add up to big savings.

The carbon footprint of a cheeseburger

Even the food we eat leaves a carbon footprint! Think of all the energy used not only to cook an average burger, but also to produce all the parts! Eating fresh and local produce helps to reduce our footprint.

The pickles: Grow the cucumbers, cook the pickle mix and transport and store the pickles.

The onions: Grow, transport and store the onions.

The cheese: Feed and milk the cows, make, transport and store the cheese.

The bun: Grow and transport the wheat, mill the flour and bake and store the bread.

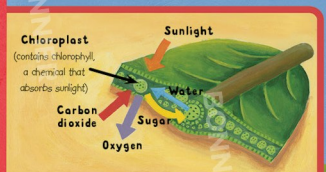
The lettuce: Grow, transport and store the lettuce.

The beef: Grow the cattle feed, heat the cowsheds, slaughter the animals and cut up, transport, grind, freeze, store and cook the meat.

Countries around the world are trying to reduce greenhouse gas emissions and to find more sustainable ways of gathering energy and producing food.

How do plants live?

Plants live by producing food from the Sun's energy. They make sugar from very simple ingredients: sunlight, water and carbon dioxide. Meanwhile, they release oxygen. This amazing process is called photosynthesis. Without plants, there would be no oxygen to breathe and no food for other living things. Animals (including us) eat plants, capturing the energy that originally came from the Sun. Awesome, isn't it?



Plants produce food inside their leaves in tiny areas called chloroplasts. Chloroplasts trap energy from the Sun, which reacts with carbon dioxide and water to make oxygen and sugar.

Sunlight

Carbon dioxide

Oxygen

Plants absorb carbon dioxide from the air and release oxygen.

Things we get from plants

Plants are very precious. We eat their leaves, seeds, fruit, roots and flowers. We use their fibres to make fabric and ropes. Some plants can be turned into medicines and perfumes. Can you imagine a world without chocolate, T-shirts, sugar, strawberries, guitars and chewing gum? These wouldn't exist without plants.

Tree houses

Trees offer food and shelter to many insects, birds and animals. An old oak tree can be home to about 350 different kinds of insect!

Forests in danger!

Tropical rainforests play a vital role on the planet. They soak up carbon dioxide from the air and release oxygen and water vapour. And they are home to more than half of the world's plant and animal species. Every six seconds, we clear an area of forest about the size of a football pitch to make space for farming, cattle ranching and mining.

The dark green area shows how much of the Amazon rainforest remains. The red line shows the forest's original size.

More than 20% of the world's oxygen is produced by the Amazon rainforest.

Every day, plants turn the Sun's energy into millions of tons of sugar.

Water and nutrients

Trees are like giant water pumps. Their roots soak up water and nutrients, which they need to grow, from the soil. These travel up to the leaves, where water vapour escapes into the air.

Why do leaves fall in the autumn?

Plants rest in the winter. They stop making food in the autumn when there is less sunlight and water. At this time, some plants drop their leaves, which saves energy and water for the winter. Leaves change colour because they stop producing chlorophyll (the chemical that absorbs sunlight and gives them their green colour).

Timber!

We use trees to make all sorts of things: houses, furniture, toys, newspapers and even this book. Wood is also burned as a fuel. It is important that we plant new trees to replace ones that have been cut down.

Rotten logs and dead leaves are feasts for fungi, bacteria, beetles, other insects and worms. These creatures slowly return the dead plants' nutrients to the soil, helping new plants to grow.

So long, soil!

Tree roots help hold the soil together. When trees are chopped down, the soil is more likely to get blown away by the wind or washed away by the rain. This makes it harder for plants to grow.

What is a food chain?

A food chain is a group of living things that depend on each other for food. All plants and animals, including us, could one day be food for something else. Plants capture their energy from the Sun, but animals eat plants or other animals for energy. Dead plants and animals are food for fungi and bacteria.

What happens if you spray pesticides to get rid of the caterpillars that eat your plants? There will be no food for the rest of the food chain!

A simple food chain

Producer

A food chain starts with a producer, usually a green plant. Plants use energy from the Sun to produce their own food.

is eaten by the...

Primary consumer

Primary consumers only eat plants. They are also called herbivores.

A consumer is a creature that eats something.

is eaten by the...

Secondary consumer

Secondary consumers eat the primary consumers. So, a sparrow might eat a caterpillar.

is eaten by the...

Tertiary consumer

Tertiary consumers eat secondary consumers. A bird of prey might eat another bird that has eaten a caterpillar. Birds of prey and other predators are called carnivores, which means meat-eaters.

is broken down by the...

Decomposer

When living things die, they become food for fungi and bacteria. Decomposers break down matter and return nutrients to the soil, which helps new plants to grow.

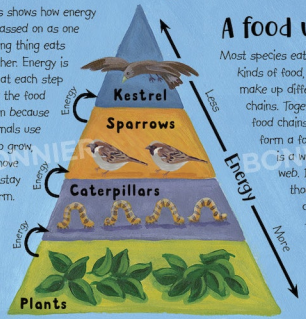
which produces nutrients for the...

Wait a minute...

Don't some animals eat both plants and animals? Yes! Like bears and pigs, humans are omnivores, meaning we can eat everything.

Pyramid of energy

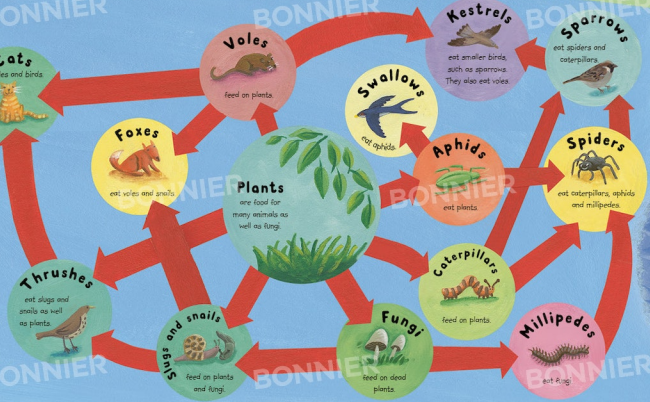
This shows how energy is passed on as one living thing eats another. Energy is lost at each step of the food chain because animals use it to grow, move or stay warm.



There are more caterpillars than sparrows because a sparrow must eat lots of caterpillars to get enough energy to survive.

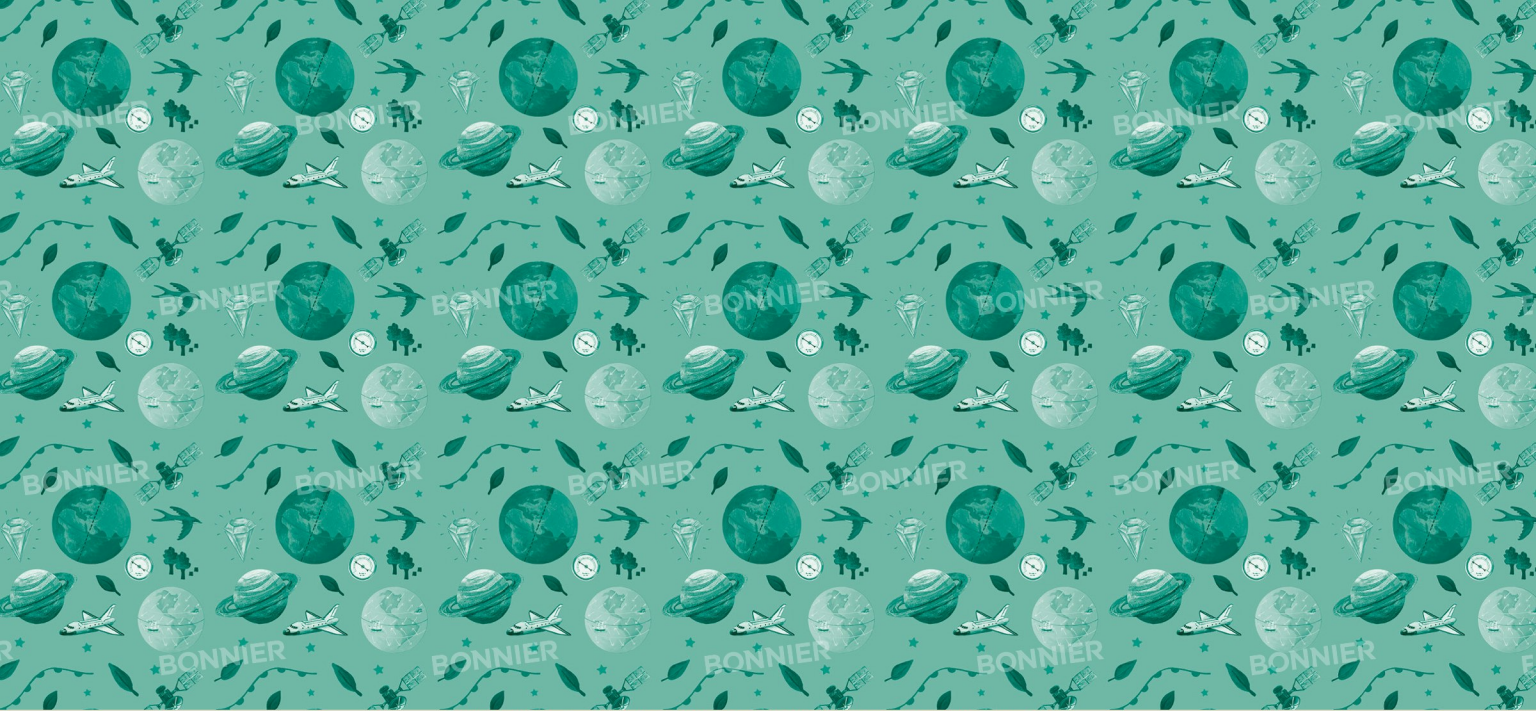
A food web

Most species eat different kinds of food, so they make up different food chains. Together, all the food chains in a habitat form a food web. Here is a woodland food web. It could contain thousands of other different species – even you, maybe!



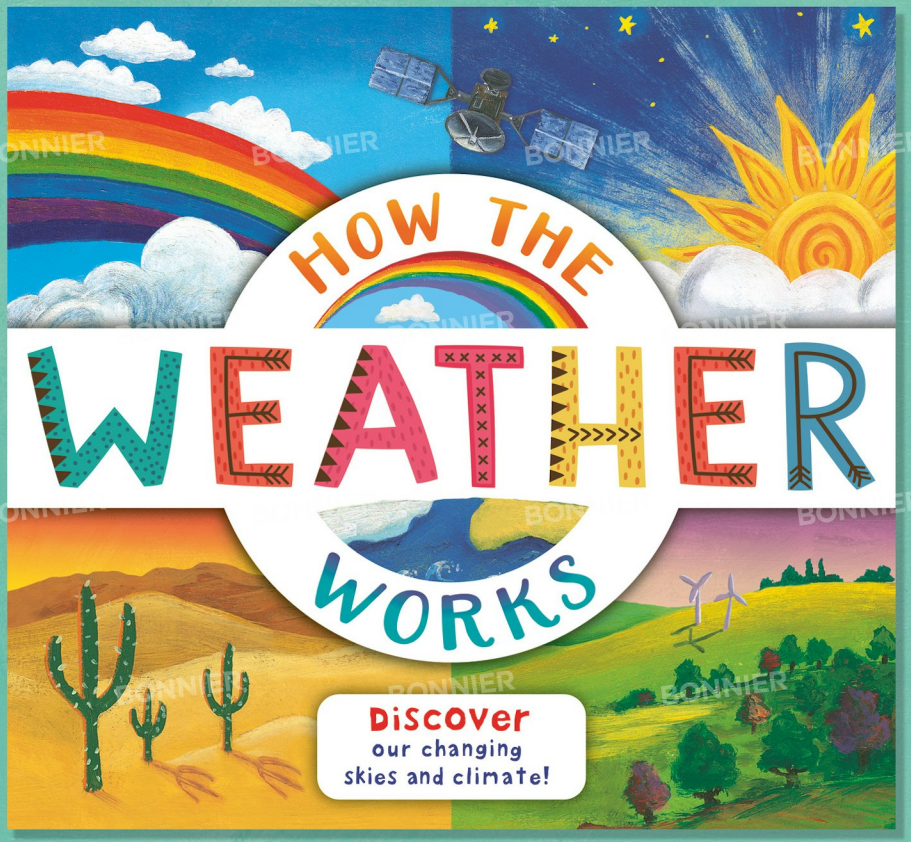
What is bioaccumulation?

It's not as complicated as it sounds! Factories and farms sometimes release pollutants into the environment. Bioaccumulation is when these build up along the food chain. Because a codfish eats thousands of shrimp, the amount of pollutants in the fish will be larger than in a single shrimp. So a polar bear at the top of the food chain ends up with the most pollutants in its body.



Now you know how the world works, discover...

How the Weather Works!



How can balloons measure the weather?

What's the link between cows and our changing climate?